# EXECUTIVE SUMMARY

## A STUDY OF COMPONENTS INFLUENCING THE DETERIORATION OF VEHICLE EMISSION CONTROL SYSTEMS

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A program was performed to investigate causes for high in-use vehicle emissions in order to identify possible improvements to the new vehicle certification process, emission component durability and future surveillance programs. Detailed emission control component calibration inspections and exhaust emission tests were performed utilizing a fleet of twenty-four 1979 to 1981 model year vehicles that were still failing by 15 percent or more after completion of a California Air Resources Board (ARB) in-use vehicle surveillance program. The study was performed by the Automotive Research Center of Olson Engineering Inc. in Huntington Beach, California. The inspection and testing phase of the study took place between August 1981 and July 1982.

Twenty-four vehicles were procured over that period of time. Fifteen were purely domestic, three were captive imports and six were imports. The vehicles were subjected to an inspection and test protocol that included:

- An initial inspection and correction of basic tuneup parameters, vacuum hose routing, and emission component installation.
- A baseline CVS-75 (FTP) emissions test.
- A complete inspection of the functional operation and calibration of emission control component parts.
- Replacement of out-of-specification components.
- A catalytic converter efficiency test.
- An additional CVS-75 emissions test to determine effectiveness of the repairs.
- Additional diagnosis and testing (as approved by the ARB project engineer) if the vehicle was still failing.

Six vehicles were found to be not eligible to complete the entire protocol. Of the eighteen vehicles completing the entire

protocol, six passed their respective emission standards after repair. Of the twelve vehicles still failing one or more standards, five were within manufacturer specifications.

Eighty-seven items were initially found to be out of adjustment, not within calibration limits or were broken upon removal.

The major functional categories of deteriorated components and adjustments and the number of occurrences are:

- Tuneup Parameters (24)
- Vacuum Management (21)
- Temperature Management (13)
- Electronic Control (11)
- Air/Fuel Control (10)
- Catalytic Converter (3)
- Exhaust Gas Recirculation - EGR (3)
- Ignition (2)

The items with the highest occurrence rates are:

- Timing Maladjustment (8 vehicles)
- Spark Plug Maladjustment, Heat Range or Fouling (8 vehicles)
- Thermostat Stuck or Out of Calibration (8 vehicles)
- Distributor Thermal Vacuum Switch Bad (6 vehicles)

The effect of individual adjustments and component replacement cannot be specifically determined. The first two items were generally corrected before the baseline emissions test was performed. All components and adjustments found to be out of calibration were generally corrected before the next emissions test was performed.

While the magnitude of the improvement for each component change or adjustment cannot be determined, the vehicles demonstrating the greatest reduction in emission levels from their baseline failing levels were those that received an original equipment

manufacturer (OEM) replacement carburetor (2), catalyst material (2) or an electronic control unit (3). The vehicles that had the high occurrence components replaced (without replacement of any of the three components just listed) demonstrated relatively modest improvements.

Every attempt was made to perform all calibration tests prescribed, but the complexity of some components and subsystems required special test equipment or procedures not available to a well equipped emissions laboratory (or to the ARB). Even manufacturer service manuals are not complete in their procedures related to calibration inspections, relying instead on functional tests and part substitution as the primary methods of diagnosis.

When diagnostic information can be provided by the on-board microcomputer (ECU), it must be extracted using a special tester or through what proved to be an unreliable method using a built-in diagnostic indicator system. Of the seven vehicles equipped with this built-in diagnostic feature, six showed either proper operation (code "12") or the code that was flashed was incorrect. The "CHECK ENGINE" light came on during engine operation for only one vehicle, but the trouble code flashed was for components that were already verified as good. The ECU was replaced in this instance. This on-board diagnostic feature is excellent in concept but appears to be limited in its ability to identify a wide range of specific faults.

The emission test results showed significant improvements in all three pollutants, without any change in fuel economy. The fleet emission levels in grams per mile and fuel economy in miles per gallon for baseline and final tests are:

| | HC | CO | NOx | MPG |
|---|---|---|---|---|
| Baseline | 0.564 | 9.307 | 1.101 | 19.177 |
| Final | 0.413 | 5.085 | 0.928 | 19.176 |
| % Change | -26.77 | -45.36 | -15.71 | -0.01 |

## FINDINGS AND CONCLUSIONS

The small size of the sample investigated and the variation in type of control system and in manufacturer render the development of conclusions somewhat difficult. Given this caveat, the following findings and conclusions are presented.

1. Most of the vehicles failing the standards were failing due to out-of-specification components.

2. The replacement of out-of-specification components brought many of the vehicles back within their prospective standards.

3. When all components are brought within manufacturer's specifications, a significant decrease in fleet emissions can be obtained.

4. Bringing all verifiable emission components within certification calibration does not ensure that the in-use vehicle will be brought into compliance with emission standards. This conclusion is supported by a recently reported agreement between General Motors and the EPA.*

5. The methods and procedures available to a well equipped emissions laboratory are not sufficient to verify that the broad range of emissions related components are within calibration. This observed limitation presumably would also apply to EPA and ARB personnel and facilities when evaluating certification applications.

6. Functional tests are not sufficient to show that individual components are within calibration since many of the failed components were still functioning, but at the wrong operating condition, or were providing erroneous "proper operation" indications in the case of several of the diagnostic ECUs.

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* "GM Prevents a Recall Via New, Clean Cars", **Automotive News**, August 9, 1982.

7. Replacement parts are not always locally available and, more significantly, when available are not always within calibration specifications. Several of the parts could only be located at the manufacturer's home warehouse. Sophisticated computer inventory searches were even used in attempts to locate parts.

8. The reasons for failure of nearly all of the components in this study cannot be specified as to whether they were due to deterioration, to in-service misuse or misadjustment or to bad components originally installed at the time of manufacture.

9. Some parts are not designed for removal, calibration verification and reinstallation. The thermal vacuum switch and coolant temperature sensor are prime examples. The plastic parts used and soft metal wrench flats make destruction upon removal very likely.

## RECOMMENDATIONS

The findings and conclusions indicate a need for better specification and control of the various emission control components. Some of the following recommendations address this problem specifically and some address it on a secondary level. The recommended approach is to provide as much meaningful information as possible from the emission data and durability data vehicles included in the certification process.

## CALIBRATION VERIFICATION PROCEDURES

It is recommended that calibration verification procedures, using generally available laboratory equipment and personnel, be included in the certification application process. By performing suitable component durability testing and verifying minimum deterioration, in-use performance can be improved.

## COMPUTER VERIFICATION OF CALIBRATION VALUES

The sophistication of modern automotive electronics is such that analog values (emission component calibrations) can be sampled periodically and be identified as out-of-specification. It is recommended that automatic compensation and/or visual displays indicating a failure be provided to ensure that emission component specifications are maintained for the useful life of the vehicle.

## EMISSION COMPONENT SELECTION

Emission critical components are presently subjected to test procedures and criteria according to the Code of Federal Regulations (40 CFR 85.2122). Appendix VIII to 40 CFR Part 85 outlines vehicle and engine parameters and specifications that are to be reported as part of the certification process. The selection of components and adjustments within the reported tolerances are assumed to be such that favorable emission levels will be obtained throughout the certification emissions test process.

It is recommended that the calibration values of components and adjustments be selected such that these components and adjustments are biased toward increased emission levels (e.g. the worst case 75th percentile of the reported calibration tolerances).

## REPORTING OF SPECIFIC CALIBRATION DATA

The specific calibration data for adjustments and individual components used in emission data and durability data vehicles are only reported at the beginning of the mileage accumulation process. Good engineering practice suggests that these data are also collected by the vehicle manufacturer at the end of the mileage accumulation process in order to assess the durability of these parts. This information can provide a valuable input to the establishment of expected stock levels for replacement parts.

It is therefore recommended that the actual measured values of these component calibrations and adjustments at both zero miles and at the completion of mileage accumulation and testing be required data and be submitted to the certifying agency as part of the certification process.

The result is likely to be the accumulation of valuable information in the establishment of a library of emission sensitive components. The ability to assign meaningful deterioration factors to individual components (or classes of components) would result and could potentially reduce the requirements of the certification process.

The identification of emission sensitive components with high rates of deterioration could allow emphasis on the calibration testing of these components and ensure an adequate supply of replacement parts, leading to more cost-effective maintenance of in-use vehicles. A complimentary effect of the

implementation of this recommendation would be more durable parts due to the requirement for non-destructive removal of the parts from durability data vehicles at 50,000 miles for calibration testing.

## SERVICE REPLACEMENTS

Replacement parts are subject to variations in performance due to manufacturing tolerances in man and machine operations. With all of the manufacturers stressing quality in their products, the tight control of these variations for emissions critical components would seem to be in line with manufacturer goals.

It is therefore recommended that a statistical sampling of emission control components be selected on a regular basis and be subjected to the same calibration test procedures used to determine calibration values of components reported on for emission and durability data vehicles. A report of this information (perhaps quarterly) would be submitted to the appropriate certifying agency.

A trial quality assessment program for emission components currently in the parts network is discussed below.

## CURRENT REPAIR PART AVAILABILITY AND CALIBRATION

It was found that several parts were unavailable at the dealer level and that those available could be out of calibration tolerance. It is recommended that a statistical sampling of testable emission system components be identified from among the major U. S. and foreign automobile manufacturers for a few major engine families. Attempts should be made to obtain these parts from various dealers and aftermarket suppliers in metropolitan areas throughout California. The delays in delivery or unavailability of the parts would be noted. Upon receipt, the calibration of each component would be determined and verified against manufacturer tolerance. Good components could be returned to the manufacturer for credit, with perhaps a restocking charge. Bad components could be installed in test vehicles to determine the effect that the failed replacement part would have had.

## VALIDATION OF EMISSIONS EFFECTS OF FAILED COMPONENTS

It is recommended that some of the failed emission components that were found during this present study be individually installed (or adjusted) to determine the effect of each failure

on emissions. Since several of the vehicles had suspect but untestable calibrations, these vehicles would not be used. Approximately eight vehicles would be needed for this validation. The same vehicles used in the current study could be solicited to provide for the same effects of manufacturing tolerance accumulation. If not available, similar vehicles would be procured. The results would be used to identify individual components that do or do not have a significant individual or combination effect on emission levels.